Appendix: Model Documentation

The model-based analyses in this report use computable general equilibrium (CGE) models and a partial equilibrium model. Beginning with the NAFTA negotiations, CGE models have become a widely used tool for evaluating the effects of trade policy reforms in both regional and multinational initiatives (U.S. International Trade Commission, 1992; Francois and Shiells, 1994; Martin and Winters, 1995). While economic theory identifies how policy changes will affect economic variables, it does not define the size of the impact and, in the case of RTA's, leaves the net effect ambiguous. CGE models provide an empirical foundation for policy analysis that can quantify the magnitudes of the effects identified by theory, and suggest the likely net effect, whether trade creating or trade diverting, of an RTA.

Each CGE model is described below, including discussion of sectoral structure, factor markets, macro closure, data sources, and any innovative features of the model, such as dynamic behavior and international labor migration.

One of the two analyses of European enlargement used a partial equilibrium model, the European Simulation Model (ESIM). This model has more disaggregation of EU agriculture than is now available in a CGE model, and includes detailed modeling of EU farm programs. ESIM is described below.

NAFTA CGE Model
(Mary Burfisher, Sherman Robinson, and Karen Thierfelder)

The NAFTA-CGE model is composed of three single-country models of the United States, Mexico, and Canada, linked by trade and labor migration flows. The model updates and extends the U.S.-Mexico CGE model built at ERS in 1991 to include Canada. The U.S.-Mexico CGE model is documented in Robinson, Burfisher, Hinojosa, and Thierfelder (1991) and Burfisher, Robinson, and Thierfelder (1994).

The NAFTA-CGE model follows the standard neoclassical specification of trade-focused CGE models. Each sector produces a composite commodity that can be transformed according to a constant elasticity of transformation (CET) function into a commodity sold on the domestic market or into an export. Output is produced according to a constant elasticity of substitution (CES) production function in primary factors and fixed input-output coefficients for intermediate inputs. The model simulates a market economy, with prices and quantities assumed to adjust to clear markets. All transactions in the circular flow of income are captured. Each country model traces the flow of income (starting with factor payments) from producers to household, government, and investors, and finally back to demand for goods in product markets.

Consumption, intermediate demand, government, and investment are the four components of domestic demand. Consumer demand is based on Cobb-Douglas utility functions, generating fixed expenditure shares. Households pay income taxes to the government and save a fixed proportion of their income. Intermediate demand is given by fixed input-output coefficients. Real government demand and real investment are fixed exogenously.

The model includes six primary factors and associated factor markets: rural labor, urban unskilled labor, urban skilled labor, professional labor, capital, and agricultural land. Land is disaggregated into irrigated and nonirrigated land in Mexico. Full employment for all categories is assumed, and aggregate factor supplies are set exogenously. In the experiments reported here, we assume that all factors are fully mobile. However, labor markets are segmented. For example, rural labor does not work in the industrial sectors and urban labor does not work in agriculture. Labor markets are linked through migration equations.

There are three key macro balances in each country model: the government deficit, aggregate investment and savings, and the balance of trade. Government savings is the difference between revenue and spending, with real spending fixed exogenously, and revenue depending on a variety of tax instruments. The government deficit is therefore determined endogenously. Real investment is set exogenously and aggregate private savings is determined residually to achieve the nominal savings-investment balance. The balance of trade for each country (and hence foreign savings) is set exogenously and valued in world prices.

Each model solves for the relative domestic prices and factor returns that clear the factor and product markets, and for an equilibrium real exchange rate which brings aggregate export supply and import demand into balance, given the exogenous aggregate trade balance of each country.

Agricultural trade policies and domestic farm programs are modeled explicitly, rather than as fixed ad valorem wedges. Policies include tariffs, tariff rate quotas, import and production quotas, input subsidies to producers and consumers, fixed guaranteed and target prices, export subsidies, and direct payments, including U.S. deficiency payments and PROCAMPO payments.

The model has 25 sectors, including 20 farm and food processing sectors and 5 nonagricultural sectors. The model base year is 1993. Data for each country are drawn from national income and product accounts, and were built into social accounting matrices by ERS under a National Research Initiative grant from CSREES/USDA. Trade data are from the United Nations. Tariff data are from the WTO. Domestic agricultural policy data are from OECD.

APEC CGE Model
(William Coyle and Zhi Wang)

This model is a recursive, dynamic, computable general equilibrium model of world production and trade. The model divides the world into 12 regions, and classes all goods and services into 12 sectors, produced by five production factors—agricultural labor, unskilled labor, skilled labor, land, and capital.

There are four sources of economic growth in the model: labor force growth, accumulation of physical capital, changes in the skill composition of the labor force, and total factor productivity (TFP) growth. The labor force growth rate is set exogenously. It was calculated from the International Labor Office's population and labor force projections from 1990 to 2020, which take the demographic structure and labor force participation rates into consideration. Capital stock in each 1-year simulation period equals the last period's capital stock plus total investment minus depreciation. No optimal behavior is assumed for investment and capital accumulation. All net investments in the previous period are assumed to become new production capital in the next period.

Agricultural labor and urban unskilled labor are not substitutable in production, but are linked by rural-urban migration flows, which are endogenous in the model and driven by the rural-urban wage differential and structural changes in production and trade. The increase in the skilled labor force is based on the growth in the stock of tertiary educated labor in each region estimated by the World Bank (Ahuja and Filmer, 1995), which provides an indication of changes in the numbers of those qualified for employment as professional and technical workers. TFP growth rates are obtained from econometric estimates by the World Bank (Vinod and Wang, 1993, Martin and Mitra, 1996).

The major data source for the model is the Global Trade Analysis Project (GTAP) database, version 3. The model was implemented in General Algebraic Modeling System (GAMS) software. Detailed description of the structure and algebraic specification of the model can be found in Wang (1997) and Wang and Schuh (forthcoming).

FTAA Model
(Xinshen Diao, Agapi Somwaru, and Terri Randy)

The model is based on neoclassical growth theory. It is a global, intertemporal (dynamic) CGE model with 10 countries/regions and 7 production sectors. The data used for calibrating the base-run are GTAP database, version 3. It is different from a static CGE model in which firms make production decisions for only one period at given level of factor endowments. In the intertemporal dynamic model, firms of each region have intertemporal optimization behavior, i.e., besides employing labor, capital and land, as well as intermediates to conduct production, firms also make investment decisions to maximize their intertemporal profits. Thus, capital accumulates over time endogenously. On the other hand, the representative consumer of each region maximizes an intertemporal utility function by making consumption and savings decisions. Thus, another difference from a static CGE model is that a country's savings is endogenously determined. This implies that the model not only captures bilateral commodity trade flows, but also financial capital flows among countries/regions over time. The intertemporal budget constraint for each country/region is equivalent to the macro-closure in the static model, but along transition, international borrowing/lending, trade deficits/surplus, and hence the accumulation of foreign debt/assets in each region

are endogenously determined. Thus, economic adjustments due to an RTA take time, and the entire transitional path to the steady state can be solved from the model.

The model also captures the linkage between trade and TFP growth by introducing *technological spillovers*. That is, if a country becomes more open in trade to other countries, it is more likely to learn and adopt advanced technologies embodied in international trade, which will improve its factor productivity, so more outputs can be produced using the same amount of productive resources. The technological spillover elasticity is borrowed from econometric studies (Coe and Helpman, 1995; Coe, Helpman and Hoffmaister, 1997; and Wang and Xu, 1997). The detailed description of the model can be found in Diao and Somwaru (forthcoming).

EC-CEEC Model
(Peter Liapis and Marinos Tsigas)

To analyze the impact of CEEC accession to the European Union (EU) we extended the Global Trade Analysis Project (GTAP) framework developed by Hertel (1997). GTAP is a global trade applied general equilibrium framework documented in Hertel and Tsigas (1997); Huff, *et al*. (1997); and Gehlhar, *et al*. (1997).

The model is calibrated to 1992 macro and trade data. GTAP has domestic and international data for 30 single-country and composite regions, and 37 commodity aggregates (McDougall, 1996). We aggregated those data to 8 regions and 16 traded commodities.

The GTAP data have tariffs and export subsidies established by the Uruguay Round Agreement (URA), and domestic support rates for 1992 (McDougall, 1996). For the EU, however, the URA commitments do not reflect the lower domestic prices which resulted from the 1992 reform of the Common Agricultural Policy (CAP). To reflect the impact of the CAP reform, we used recent border policies for agriculture in the EU and CEEC-7 (Hertel, *et al.* 1997).

GTAP is a comparative static model with price-taking behavior for all economic agents and full employment of resources. Land is employed in agriculture only, and it is imperfectly mobile across sectors. All sectors employ labor and capital, which are perfectly mobile across sectors in a region. Households maximize

utility derived from consumption and savings subject to regional income, which consists of primary factor payments and net tax collections. International trade clears commodity markets, with each commodity being differentiated by its place of origin. Regional investment is financed by domestic savings and net capital inflow from all other regions. A price index for global savings is the numeraire.

To consider impacts on the costs of the CAP, we modified the GTAP model by including a budget component for the CAP. We determine CAP expenditures, given our policy assumptions, and an income tax rate needed to generate the necessary revenue to finance those expenditures.

Global CGE Model
(Mark Gehlhar)

This analysis uses the GTAP model as described above (see Liapis and Tsigas). To simulate the effects of multiple RTA's throughout the world, the standard GTAP model was used with a 10-region/country aggregation. This regional breakdown consists of the individual NAFTA countries, the MERCOSUR, Chile, other APEC countries, the EU, Central and Eastern European Countries, and the rest of the world. The sectoral breakdown consisted of a 6-sector aggregation which was aggregated from the 37-sector GTAP database.

ESIM Model

The European Simulation models (ESIM) are linear, time-dependent, constant elasticity, partial equilibrium models. ERS currently has five individual country/region ESIM models (EU-15, the Czech Republic, Hungary, Poland, and Slovakia) and the EU-18 model used for this analysis (EU-15 plus the Czech Republic, Hungary, and Poland). ESIM covers 18 major commodities in the agricultural sector: wheat, corn, barley, other coarse grains, soybeans, rapeseed, sunflowerseed, soymeal, rapemeal, sunmeal, soyoil, rapeoil, sunoil, other oils, fluid milk, beef and veal, pork, and poultry. ESIM also includes 12 feeds and a detailed feeding scheme. It was developed by Jan Blom of LEI/DLO in the Netherlands.

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